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BOX PATENT APPLICATION
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DOCKET NUMBER: 12179-P064US

Sir:

Transmitted herewith for filing is the Patent Application of:

Inventor: Zhidan L. Tolt et al.

For: A PROCESS FOR GROWING A CARBON FILM

Enclosed are:

- ☒ Patent Specification and Declaration
- ☒ 10 sheets of drawing(s)
- ☒ An assignment of the invention to SI Diamond Technology, Inc. (includes Recordation Form Cover Sheet).
- ☐ A certified copy of a ___ application.
- ☐ An associate power of attorney
- ☐ Information Disclosure Statement, PTO 1449 and copies of references.
- ☒ Verified Statement Claiming Small Entity Status

The filing fee has been calculated as shown below:

For	Number Filed	Number Extra	Rate Small Entity	Fee Small Entity
Basic Fee				\$ 385.00
Total Claims	25 - 20	5	x 11 =	\$ 55.00
Indep. Claims	3 - 3	0	x 40 =	\$ - 0 -
<input type="checkbox"/> MULTIPLE DEPENDENT CLAIM(S) PRESENTED			+ 130 =	\$ - 0 -
			TOTAL	\$ 440.00

- ☒ A check in the amount of \$ 440.00 is enclosed for the filing fee and a check for \$ 40.00 is enclosed for the assignment fee..
- ☒ The Assistant Commissioner is hereby authorized to charge payment of the following fees associated with this communication or credit any overpayment to Deposit Account No. 23-2426 (12179-P064US). A duplicate copy of this sheet is enclosed.
 - ☒ Any additional filing fees required under 37 CFR §1.16
 - ☒ Any patent application processing fees under 37 CFR §1.17.

Respectfully submitted,

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A PROCESS FOR GROWING A CARBON FILM

CROSS-REFERENCE TO RELATED APPLICATION

5 This application for patent is related to copending U.S. Patent Application
Serial No. 08/_____ [Attorney Docket No. 12179-P065US] entitled "A
Field Emission Device," which has been filed concurrently herewith.

TECHNICAL FIELD

10 The present invention relates in general to growing carbon films, and in
particular, to growing a carbon film on a treated substrate.

BACKGROUND INFORMATION

15 Field emission display devices show promise in providing a low cost
alternative to LCD displays, especially with respect to laptop computers.
Furthermore, field emission devices are beginning to be practically applied in other
areas, such as billboard-type display devices.

One of the challenges in producing a good field emission device or display is the manufacture of a field emitter material, which is inexpensive to manufacture yet efficient with respect to power consumption and consistent in its display characteristics. Carbon and/or diamond field emitter materials have shown promise in meeting such constraints.

One of the problems with present methods for depositing such films for use in a matrix addressable display is that in order to pattern the film these processes utilize one or more treatment (e.g., etching) steps after a film has already been deposited on the substrate. Such treatment steps degrade the film's performance and emission capabilities, often to the point where the film emissions are inadequate. As a result, there is a need in the art for a deposition process whereby post-deposition processes performed on the film are not utilized.

SUMMARY OF THE INVENTION

5 The foregoing need is addressed by the present invention, which utilizes a process whereby a patterned cathode is produced without processing (e.g., etching) the emission film. This is accomplished by performing a treating step on the substrate prior to deposition, which may be comprised of a ceramic material such as fosterite. This treating step may be performed to etch a metal layer that has been previously deposited on the substrate in order to pattern the metal material. After the treating step, then the film is deposited over the entire sample. The number of nucleation sites is greater at the locations where there is no metal resulting in preferential emissions at the sites.

10 In an alternative embodiment, the material is deposited through a mask whereby the holes in the mask correspond to the areas where the metal layer has been etched away.

15 In one embodiment, the film deposited, or grown, on the substrate is a diamond or diamond-like film.

In another embodiment of the present invention, the film deposited, or grown, on the substrate is a carbon which is a mixture of diamond particles and graphite particles and amorphous carbon or a subset of this mixture whereby one or more of these materials is present. Such particles may be crystalline.

20 In another alternative embodiment of the present invention, the film is grown on a substrate after the substrate has been treated with either a base ($\text{pH} > 7$)

or an acid ($\text{pH} < 7$). The substrate may be a ceramic or glass-like material, and may be polished or unpolished previous to the treating step. The treatment, or etching, of the substrate changes the micro-morphology of the substrate (*i.e.*, it "roughens" the surface of the substrate) thus providing a preferential surface for the film to be grown.

In yet another alternative embodiment of the present invention, a sonication process on the treated substrate may be employed to further enhance the growth of the film on the substrate.

In yet another alternative embodiment of the present invention, the substrate may be comprised of a metal, or conductive, material.

An advantage of the present invention is that the film grown on the treated portion of the substrate is a better electron emitting material than the film grown on the untreated portion of the substrate. The result of this advantage is that a pattern can be easily formed of the emission sites without having to perform any type of etching steps after the film has already been grown, or deposited.

The foregoing has outlined rather broadly the features and technical advantages of the present invention in order that the detailed description of the invention that follows may be better understood. Additional features and advantages of the invention will be described hereinafter which form the subject of the claims of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

FIGURES 1-6 illustrate a deposition process in accordance with the present invention;

FIGURE 7 illustrates a flow diagram in accordance with the present invention;

FIGURE 8 illustrates a field emission device manufactured with a film in accordance with the present invention;

FIGURE 9 illustrates a data processing system utilizing a display device manufactured with a field emitter in accordance with the present invention;

FIGURE 10 illustrates a flow diagram of an alternative process for producing a film in accordance with the present invention;

FIGURES 11-14 illustrate images of emission from a cathode manufactured in accordance with the present invention; and

FIGURES 15 and 16 illustrate graphs showing the disparity in emission properties between a film grown on a treated substrate and a film grown on an untreated substrate.

DETAILED DESCRIPTION

In the following description, numerous specific details are set forth to provide a thorough understanding of the present invention. However, it will be obvious to those skilled in the art that the present invention may be practiced without such specific details. In other instances, well-known circuits have been shown in block diagram form in order not to obscure the present invention in unnecessary detail. For the most part, details concerning timing considerations and the like have been omitted inasmuch as such details are not necessary to obtain a complete understanding of the present invention and are within the skills of persons of ordinary skill in the relevant art.

Refer now to the drawings wherein depicted elements are not necessarily shown to scale and wherein like or similar elements are designated by the same reference numeral through the several views.

Referring to FIGURES 1-7, there is illustrated a process for producing a film for a field emission device in accordance with the present invention. In step 701, a substrate 101, which may be comprised of glass, a ceramic, or fosterite, a metal (or any other suitable material) is cleaned and then coated (step 702) with 1400 angstroms of titanium (Ti) by electron-beam (e-beam) evaporation. Thereafter, 2000 angstroms of titanium-tungsten (TiW) is deposited onto the sample by a sputtering process. Note, however, that any process for depositing a metal layer 102 on a substrate 101 may be utilized.

Thereafter, in step 703, the metal layer 102 is patterned in a desired manner using photolithography. A photoresist layer 201 is deposited on the metal layer 102 and then patterned using well-known techniques. As illustrated in FIGURES 1-6, the pattern may be an array of open windows developed in the photoresist film. However, please note that any pattern design may be employed.

Next, in step 704, the metal layer 102 is etched, resulting in windows 301 within the metal layer 102. The photoresist layer 201 can then be removed using well-known techniques. The etching step 704 may be performed with seven minutes of a tungsten etchant and then 20-30 seconds of a titanium etchant. Other well-known etchants may be utilized for step 704. The etching process is performed for a sufficient amount of time so that these etchants roughen the surface of the substrate 101. The etchant used to remove the metal layer 102 also attacks the substrate 101. Because the substrate 101 is not perfectly uniform, the etchant attacks some areas of the substrate 101 stronger than other areas. This leaves the surface of the substrate 101 pitted and rough. Surface treatments by acids and bases may also change the chemical composition of the substrate surface as well as change the morphology. For example, certain treatments may leave the surface of a substrate terminated with bonds to hydrogen or fluorine atoms. If the substrate is a composition of different materials, the treatment may result in leaving the surface with a different composition than the bulk material of the substrate. Because, the CVD growth process often involves chemical reactions with the substrate surface, treatments that change the chemical composition of the

substrate surface may result in a surface that initiates film growth more favorably than an untreated surface.

5 Step 704 may or may not involve a sonication step, whereby the sample is emersed in a diamond slurry and sonicated. An advantage to not performing the sonication step is that sonication processes in a diamond slurry can damage metal feedline patterns on the substrate 101 as well as add time and expense in manufacturing a cathode. Furthermore, the sonication step is not easily discriminating as to which areas are treated.

10 The result of these steps is a sample that has a substrate with a metal film grid pattern coated on one side. Inside the windows 301 of the grid is an etch-treated substrate 101.

15 The sample is then subjected to a CVD (chemical vapor deposition) carbon film growth process in step 705. Both the treated 301 and the untreated metal coated area 102 are equally exposed to the CVD active gas species (see FIGURE 5). The film prefers to nucleate on a defect (i.e., the film preferentially grows on the treated area). Such defects within the substrate 101 have been previously caused by the roughening of the surface of the substrate 101 during the etching step. This etching step causes many tiny defects in the surface of the substrate 101, which provides nucleation sites for grains. As a result, the etching
20 step 704 increases the number of nucleation sites for the deposition of the layer in step 705. Therefore, the resultant layer 501 emits from the windows 301 and not from the areas above the metal layer 102 (the emission site density on the treated

area is more than an order of magnitude higher than on the metal (untreated) area). This is because there is an enhanced growth of the film due to the enhanced nucleation. The present understanding of the technology is that emission takes place from diamond nucleation sites that have small grains of diamond.

5 Depositing longer to create more nucleation sites only results in larger grains, not more of them. Thus, areas of higher nucleation density will also be areas of higher emission site density. Furthermore, the extraction field for the film in the window is made lower than that on the metal layer. The emission site density on the window is also at least one order of magnitude higher and as a result, the film
10 on the window area emits preferentially.

The deposition process of step 705 may be performed using a chemical vapor deposition process, which may be assisted with a hot-filament process. This deposition process may result in the growing of a carbon film on the sample.

As can be noted, an advantage of this process is that microelectronics type
15 processing, such as the etching steps, need not be performed subsequent to deposition of a carbon layer, so that the carbon layer is not subject to such processes. This results in a better emitting film and damage to the emitting film is prevented.

Referring next to FIGURE 6, there is illustrated a top view of the portion
20 of the sample illustrated in FIGURE 5. As can be seen, emission sites are located at windows 301, and the metal layer 102 surrounds each of these windows 301. A matrix-addressable display can be manufactured whereby windows 301 aligned in a

vertical row may all correspond to each other whereby each such row is energized by the metal layer 102 corresponding to that row, and the metal strips 102 are individually addressed.

Referring next to FIGURE 10, there is illustrated an alternative process for depositing a film, whereby the substrate 101 is prepared in the same manner in step 1001 as in step 701. However, the treating and metal layer deposition steps are reversed from that described above with respect to FIGURE 7. In step 1002, the substrate 101 is treated (e.g., etched). This may be performed with or without a photolithography process. If a photolithography process is utilized, then a photoresist pattern may be deposited on the substrate so that the etching step only etches at locations 301. Thereafter, in step 1003, the metal layer is deposited through a mask whereby holes in the mask correspond to all portions of the sample besides the windows 301 so that the resultant metalization pattern is achieved as in FIGURE 5. After step 1003, the layer 501 is deposited in step 1004.

Optionally, step 1003 may be deleted. Furthermore, optionally, step 1003 may be performed using a standard photolithography process.

Referring next to FIGURE 8, there is illustrated field emitter device 80 configured with a film produced by either of the processes illustrated in FIGURES 7 and 10. Device 80 could be utilized as a pixel within a display device, such as within display 938 described below with respect to FIGURE 9.

Device 80 also includes anode 84, which may comprise any well-known structure. Illustrated is anode 84 having a substrate 805, with a conductive

strip 806 deposited thereon. Then, phosphor layer 807 is placed upon conductive film 806. An electrical potential $V+$ is applied between anode 84 and cathode 82 as shown to produce an electric field, which will cause electrons to emit from film 501 towards phosphor layer 807, which will result in the production of photons through glass substrate 805. Note that an alternative embodiment might include a conductive layer deposited between film 501 and substrate 101. A further alternative embodiment may include one or more gate electrodes (not shown).

The gap between anode 84 and cathode 82 may be 0.75 millimeters (750 microns).

Referring next to FIGURES 11-13, there are shown actual images of photon emission from device 80 taken with different applied voltages, and hence, different applied fields between the anode 84 and the cathode 82. The images in FIGURES 11-13 were taken by applying a pulsed voltage at 1000Hz frequency with a 10 microsecond pulse width. The gap between anode and cathode was 0.75 mm. In FIGURE 11, the peak emission current was 4 mA with an applied voltage of 3230 volts. In FIGURE 12, the peak emission current was 40 mA with an applied voltage of 4990 volts. In FIGURE 13, the peak emission current was 20 mA with an applied voltage of 3720 volts. As can be readily seen, light is generated in the phosphor screen 84 only in the areas where electrons from the cathode 82 strike the phosphor 807. It is seen in FIGURES 11-13 that the area of the substrate 101

that was subjected to the etching process is the area from where electron emission occurs.

FIGURE 14 shows a similar actual image from a similar test except that the gap between the anode 84 and cathode 82 is much smaller (43 microns) and the camera set-up to take this image provided a higher resolution image. Again, one can see from the lighted areas of the phosphor that the area on the cathode 82 that was subjected to the etching process is the area from where almost all the electron emission occurs.

Because the emission sites from the etched area dominate the emission properties on this particular sample, it is not possible to get a direct measure of emission properties of the untreated area directly. As a result, in order to compare experimentally the emission properties between an etched area and an unetched area, another sample, which was not treated to the etching step wherein the metal layer was left intact, was produced and a carbon film was grown on top of the metal layer with the same CVD process that was used to grow the carbon film on the pattern sample illustrated above in FIGURES 11-14.

FIGURE 15 illustrates a comparison of the emission site density between the treated and untreated areas as a function of the applied field. The treated, or etched area had the emission properties illustrated by line 1500, while the unetched area had emission properties as shown by line 1501.

FIGURE 16 shows a comparison of the emission site density between treated and untreated areas as a function of electron emission current density.

Again, the treated, or etched area, had such properties as illustrated by line 1600, while the unetched area had the properties illustrated by line 1601.

One can see that the properties of the treated areas are superior to the untreated areas in that they have higher emission site densities at lower extraction fields and achieve overall higher emission site densities. With proper field control, only the treated area has electron emission.

As noted above, field emitter device 80 may be utilized within field emission display 938 illustrated in FIGURE 9. A representative hardware environment for practicing the present invention is depicted in FIGURE 9, which illustrates a typical hardware configuration of workstation 913 in accordance with the subject invention having central processing unit (CPU) 910, such as a conventional microprocessor, and a number of other units interconnected via system bus 912. Workstation 913 includes random access memory (RAM) 914, read only memory (ROM) 916, and input/output (I/O) adapter 918 for connecting peripheral devices such as disk units 920 and tape drives 940 to bus 912, user interface adapter 922 for connecting keyboard 924, mouse 926, speaker 928, microphone 932, and/or other user interface devices such as a touch screen device (not shown) to bus 912, communication adapter 934 for connecting workstation 913 to a data processing network, and display adapter 936 for connecting bus 912 to display device 938. CPU 910 may include other circuitry not shown herein, which will include circuitry commonly found within a

microprocessor, e.g., execution unit, bus interface unit, arithmetic logic unit, etc.
CPU 910 may also reside on a single integrated circuit.

5 Although the present invention and its advantages have been described in
detail, it should be understood that various changes, substitutions and alterations
can be made herein without departing from the spirit and scope of the invention as
defined by the appended claims.

WHAT IS CLAIMED IS:

- 1 1. A method for making a field emitter device comprising the steps of:
2 providing a substrate;
3 treating said substrate to modify a morphology of said substrate; and
4 growing a carbon film on said treated substrate.
- 1 2. The method as recited in claim 1, wherein only a portion of said substrate
2 is subjected to said treating step, and wherein said carbon film grown on said
3 treated substrate is a better field emitter than carbon film grown on an untreated
4 portion of said substrate.
- 1 3. The method as recited in claim 2, wherein said carbon film grown on said
2 treated portion of said substrate emits substantially more electrons when subjected
3 to a specified electric field than said carbon film on said untreated substrate.
- 1 4. The method as recited in claim 1, wherein said substrate is treated with a
2 base, wherein said treating step changes the chemical composition of said surface
3 of said substrate.
- 1 5. The method as recited in claim 1, wherein said substrate is treated with an
2 acid.

- 1 6. The method as recited in claim 5, wherein said substrate is a ceramic.
- 1 7. The method as recited in claim 5, wherein said substrate is a metal.
- 1 8. The method as recited in claim 5, wherein said substrate is a glass.
- 1 9. The method as recited in claim 1, further comprising the step of performing
2 sonication on said substrate.
- 1 10. The method as recited in claim 3, wherein said substrate was not subjected
2 to a sonication step.
- 1 11. The method as recited in claim 1, further comprising the steps of:
2 depositing a metal layer on said substrate whereby said metal layer has a
3 predefined pattern so that a portion of said substrate is accessible through said
4 metal layer, wherein said depositing step is performed before said growing step.
- 1 12. The method as recited in claim 11, wherein said step of growing said
2 carbon film also deposits said carbon film on said metal layer, wherein said carbon
3 film is a continuous film.

- 1 13. The method as recited in claim 11, wherein said step of depositing said
2 metal layer on said substrate further comprises the steps of:
3 depositing said metal layer on said substrate;
4 patterning said metal layer using photolithography; and
5 etching said metal layer producing said predefined pattern.

1 14. A field emitter device manufactured by the following steps:
2 providing a substrate;
3 treating said substrate to modify a morphology of said substrate; and
4 growing a carbon film on said treated substrate, wherein only a portion of
5 said substrate is subjected to said treating step, and wherein said carbon film
6 grown on said treated substrate is a better field emitter than carbon film grown on
7 an untreated portion of said substrate, wherein said carbon film grown on said
8 treated portion of said substrate emits substantially more electrons when subjected
9 to a specified electric field than said carbon film on said untreated substrate.

1 15. The device as recited in claim 14, wherein said substrate is treated with an
2 acid.

1 16. The device as recited in claim 15, wherein said substrate is a ceramic.

- 1 17. A method for depositing a carbon film comprising the steps of:
2 depositing a metal layer on a substrate whereby said metal layer has a
3 predefined pattern so that a portion of said substrate is accessible through said
4 metal layer; and
5 depositing said carbon film on said portion of said substrate.
- 1 18. The method as recited in claim 17, wherein said step of depositing said
2 carbon film also deposits said carbon film on said metal layer.
- 1 19. The method as recited in claim 18, wherein said carbon film is a continuous
2 film.
- 1 20. The method as recited in claim 17, wherein said step of depositing said
2 metal layer on said substrate further comprises the steps of:
3 depositing said metal layer on said substrate;
4 patterning said metal layer using photolithography; and
5 etching said metal layer producing said predefined pattern.
- 1 21. The method as recited in claim 20, wherein said etching step roughens a
2 surface of said substrate at said portion of said substrate.

1 22. The method as recited in claim 21, wherein said substrate is a ceramic-like
2 material.

1 23. The method as recited in claim 17, wherein said step of depositing said
2 metal layer on said substrate further comprises the steps of:
3 etching said substrate, wherein said etching step changes the chemical
4 composition of said surface of said portion of said substrate; and
5 depositing said metal layer on said substrate through a mask producing said
6 predefined pattern.

1 24. The method as recited in claim 23, wherein said etching step roughens a
2 surface of said substrate.

1 25. The method as recited in claim 20, wherein said etching step changes the
2 chemical composition of said surface of said portion of said substrate.

A PROCESS FOR GROWING A CARBON FILM

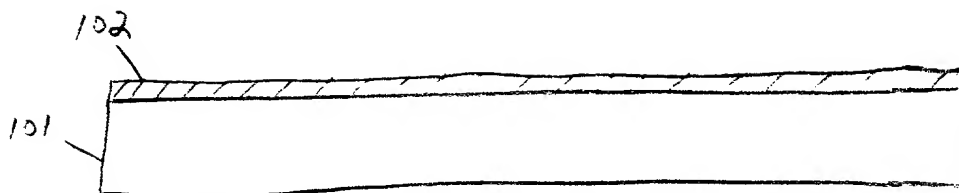
ABSTRACT OF THE DISCLOSURE

5

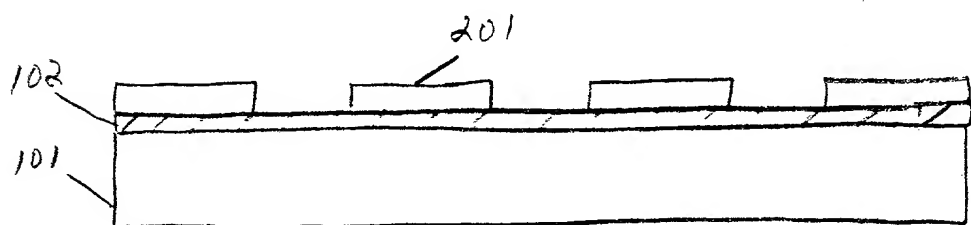
A film (carbon and/or diamond) for a field emitter device, which may be utilized within a computer display, is produced by a process utilizing etching of a substrate and then depositing the film. The etching step creates nucleation sites on the substrate for the film deposition process. With this process patterning of the emitting film is avoided. A field emitter device can be manufactured with such a film.

10

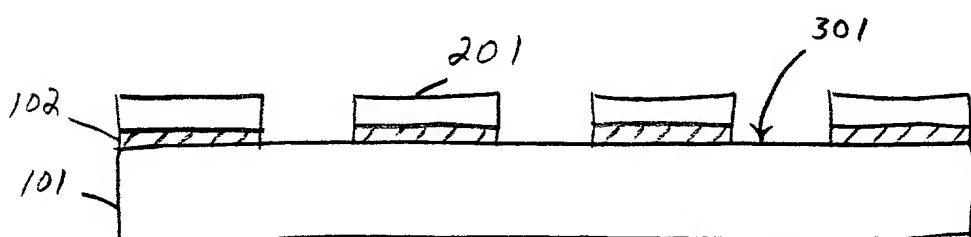
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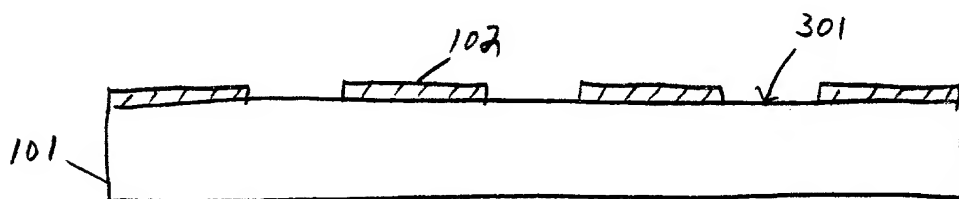
F16.1



F16. 2



F16. 3



F16. 4

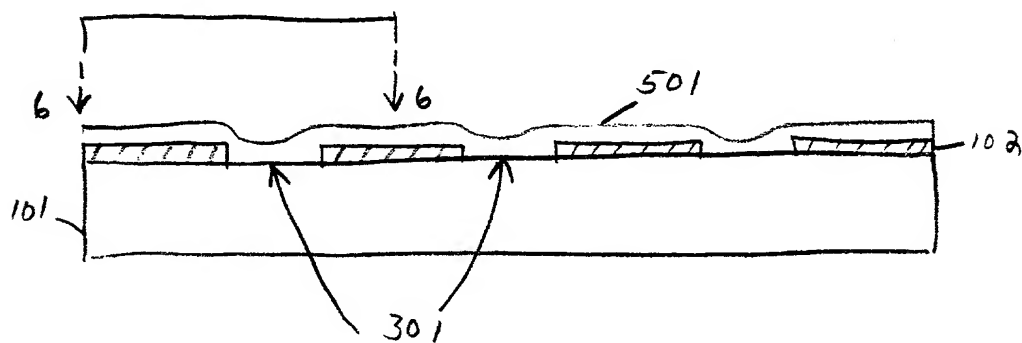


FIG. 5

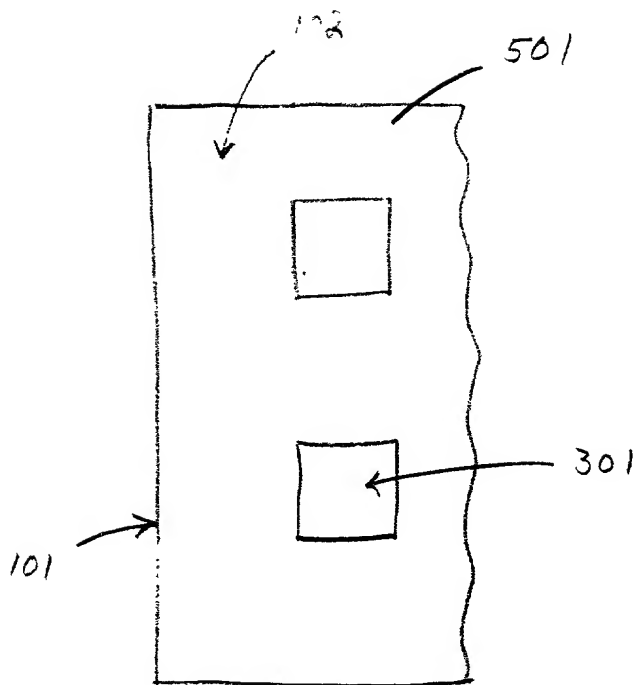


FIG. 6

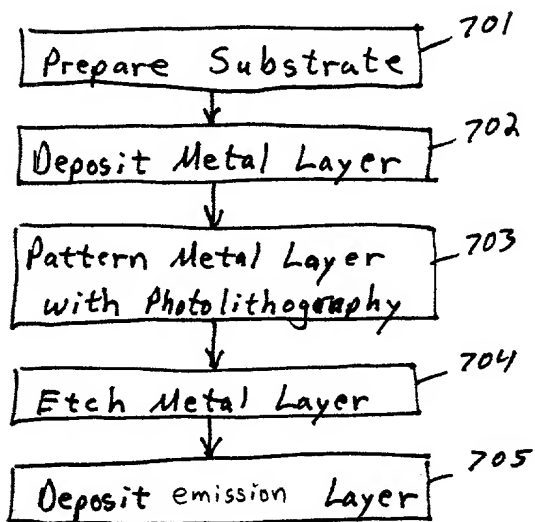


FIG. 7

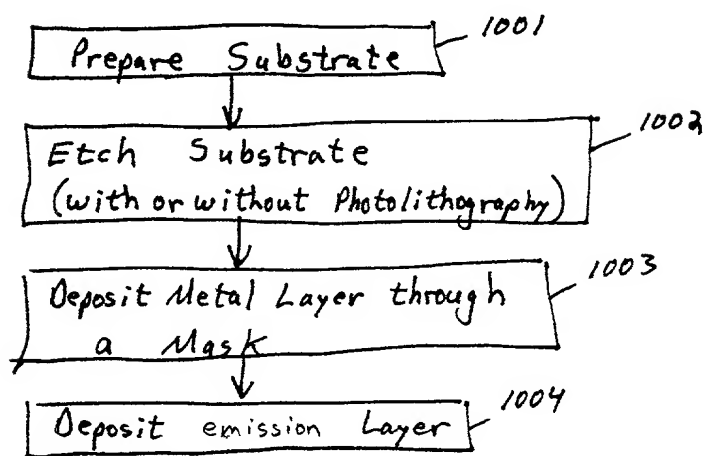


FIG. 10

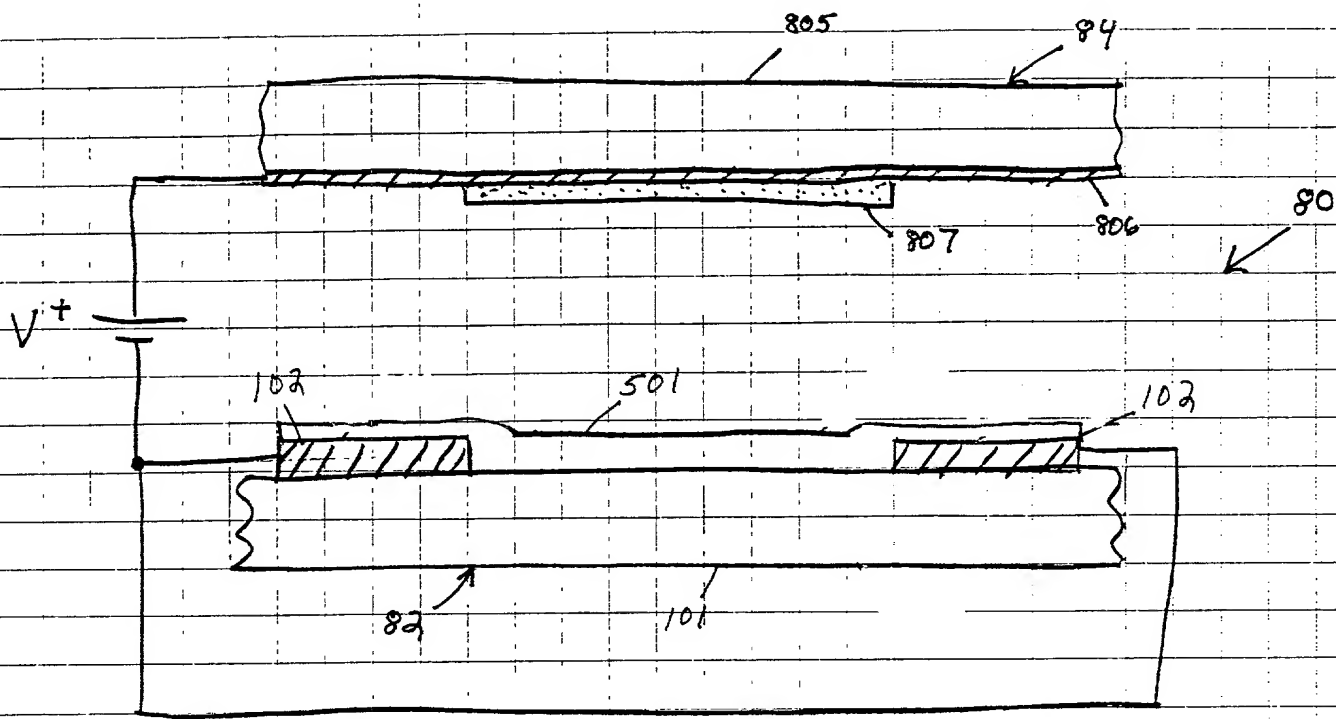


FIG. 8

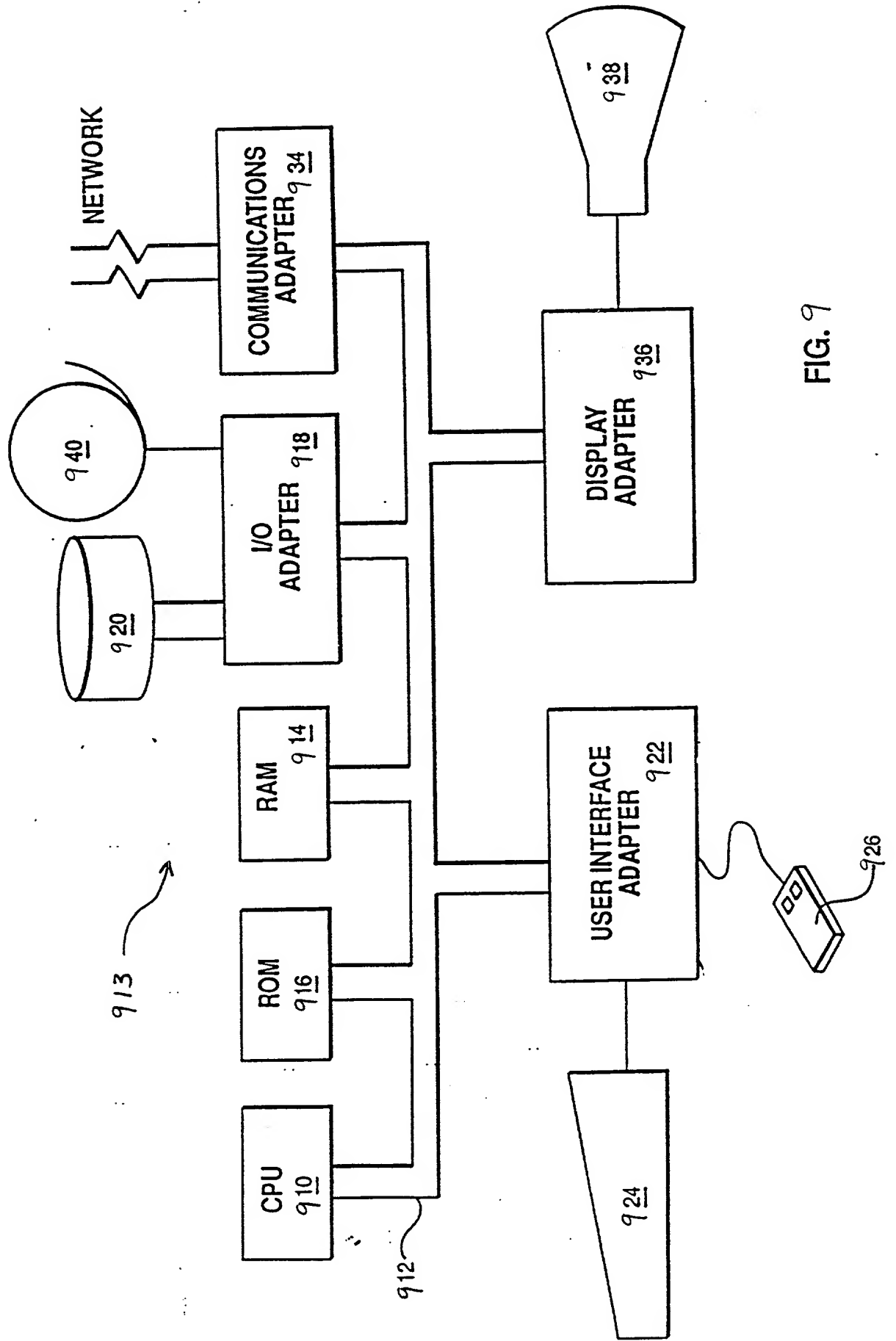
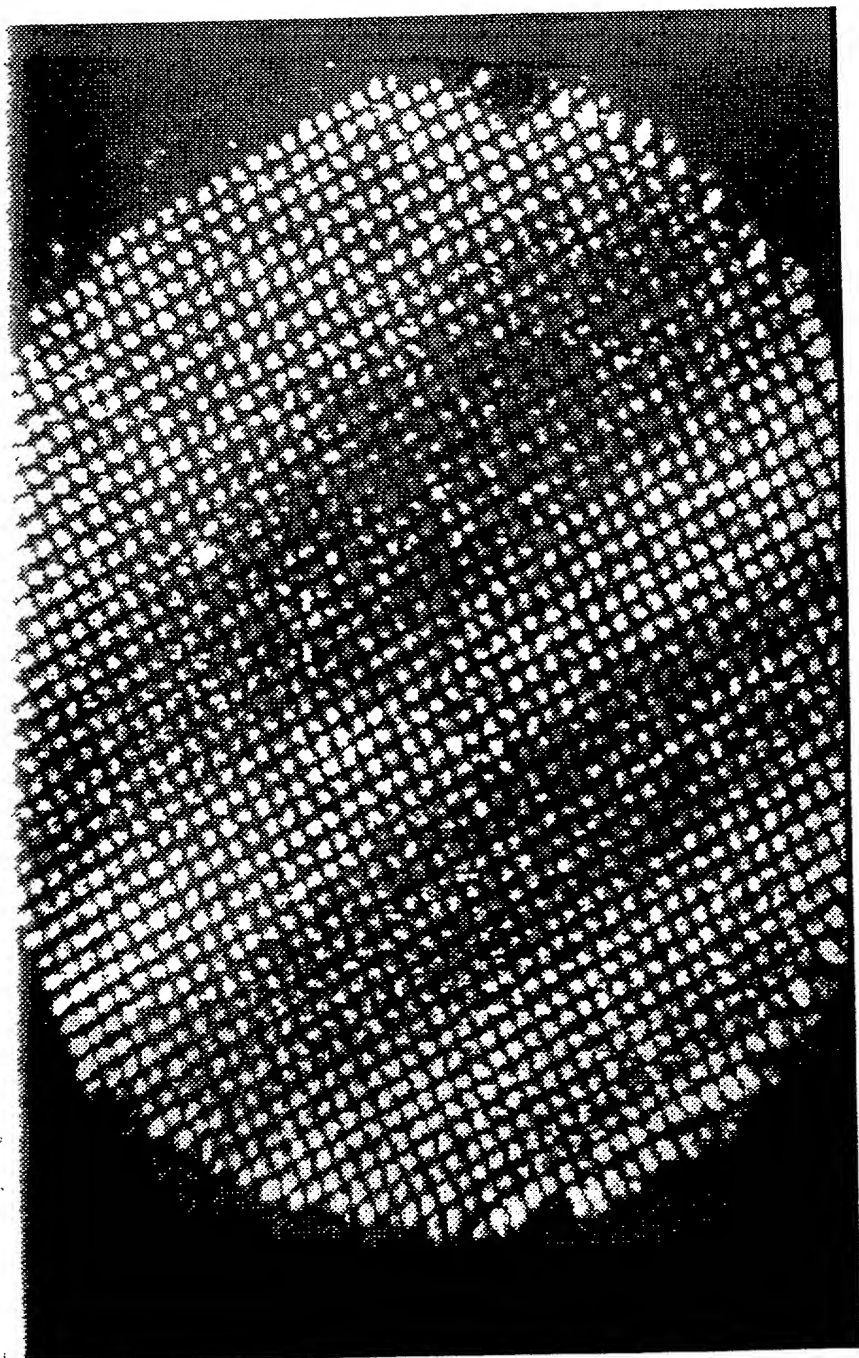


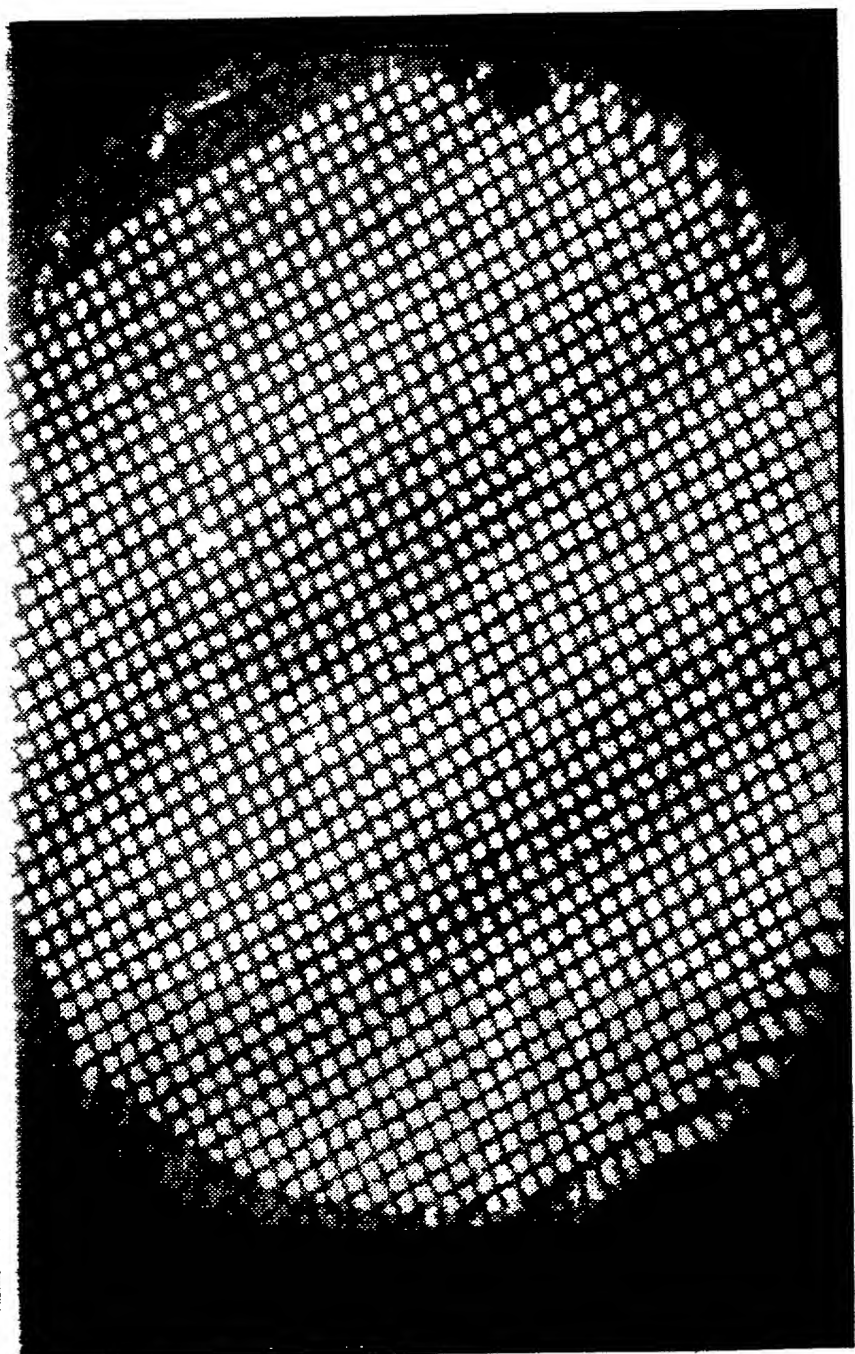
FIG. 9

Figure 11



00000000-000000

Figure 12



00000000.052197

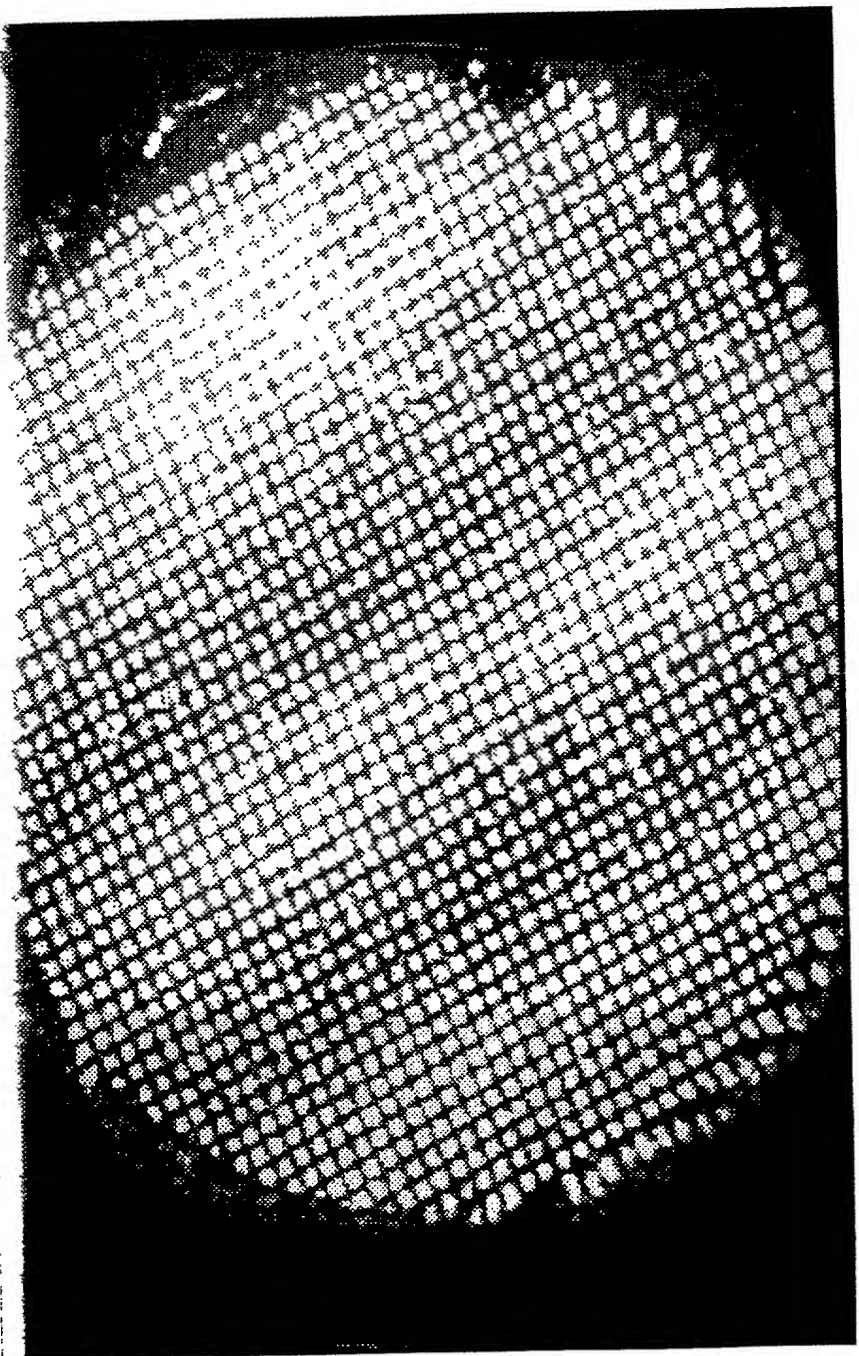


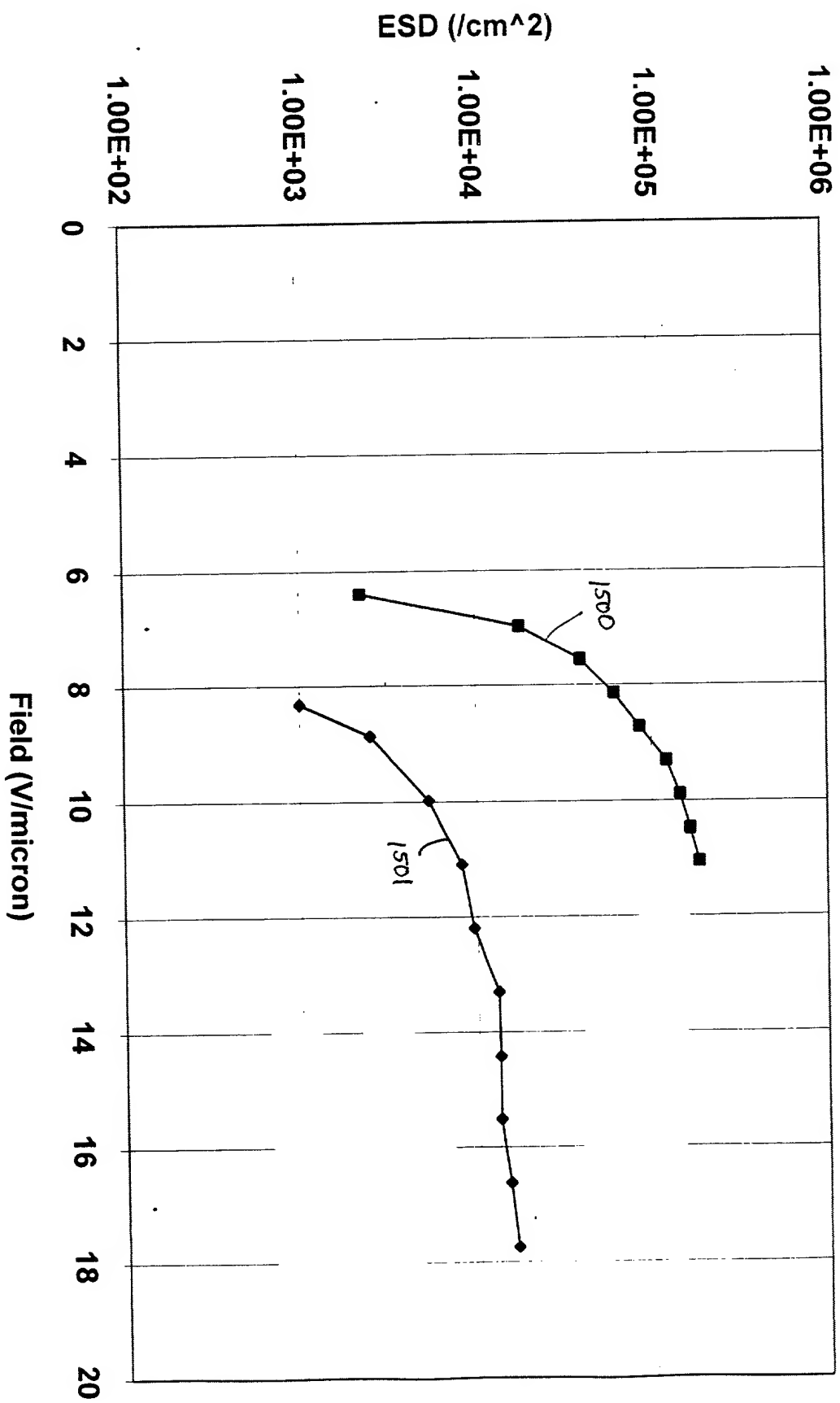
Figure 13

00050960-052197

Figure 14

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415	2416	2417	2418	2419	2420	2421	2422	2423	2424	2425	2426	2427	2428	2429	2430	2431	2432	2433	2434	2435	2436	2437	2438	2439	2440	2441	2442	2
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Emission Site Density vs. Applied Field



Emission Site Density vs Current Density

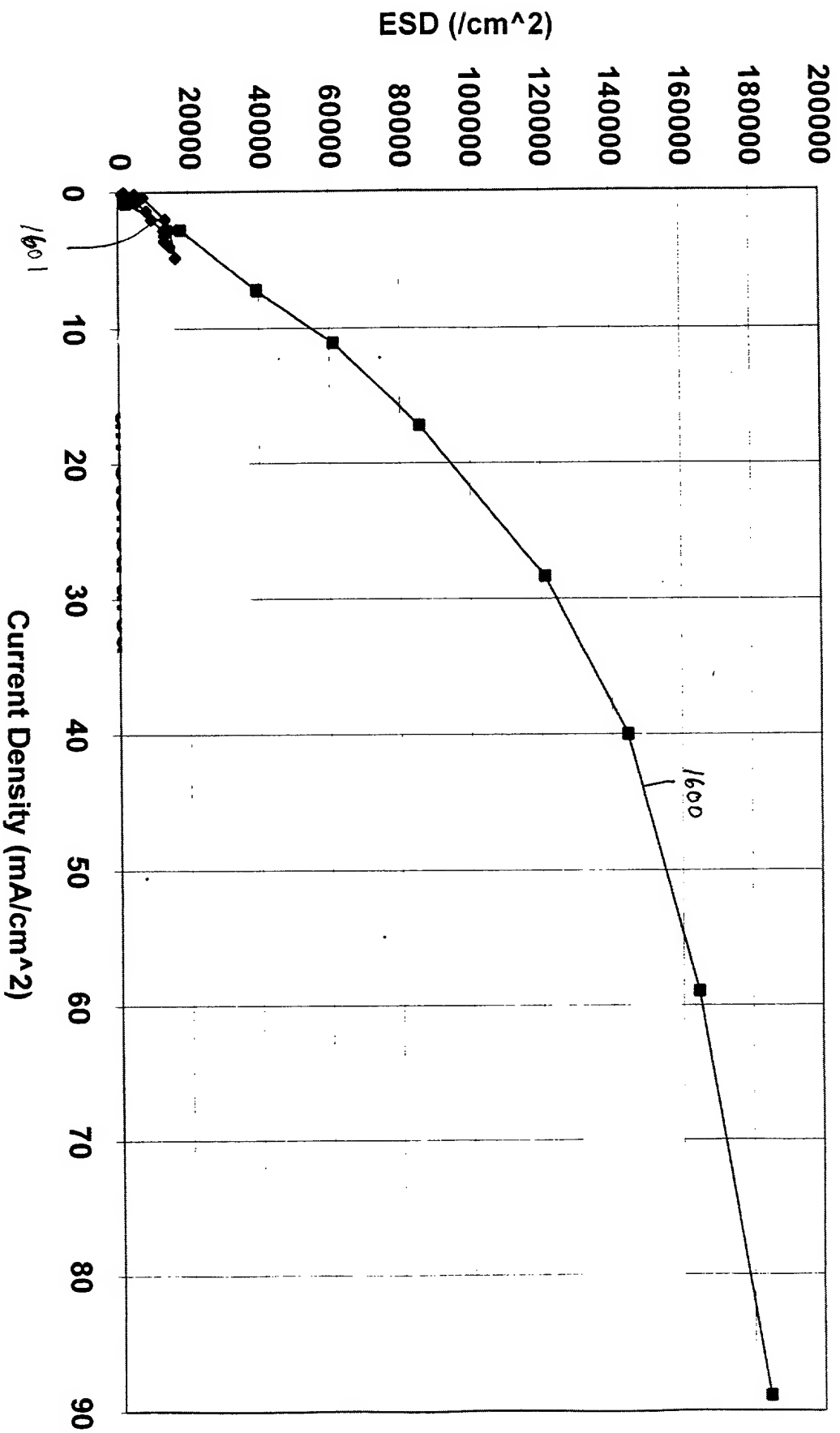


Figure 16

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**DECLARATION AND POWER OF ATTORNEY FOR
PATENT APPLICATION**

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

A PROCESS FOR GROWING A CARBON FILM

the specification of which (check one)

- ☒ is attached hereto.
- ☐ was filed on _____
as Application Serial No. _____
and was amended on _____

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s):

Priority Claimed

 (Number) (Country) (Day/Month/Year) ☐ Yes ☐ No

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose information material to the patentability of this application as defined in Title 37, Code of Federal Regulations, §1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

 (Application Serial #) (Filing Date) (Status)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorneys and/or agents to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

Kelly K. Kordzik, Reg. No. 36,571; Elizabeth A. Apperley, Reg. No. 36,428; Gregory W. Carr, Reg. No. 31,093; James J. Murphy, Reg. No. 34,503; and Robert D. McCutcheon, Reg. No. 38,717.

Send correspondence to: James J. Murphy, 5400 Renaissance Tower, 1201 Elm Street, Dallas, Texas 75270-2199, and direct all telephone calls to Kelly K. Kordzik at (512) 370-2851.

12179-P064US

PATENT



FULL NAME OF SOLE OR FIRST INVENTOR: **ZVI YANIV**

INVENTOR'S SIGNATURE: [Signature] DATE: 5/21/97

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Bloomfield Hills, Oakland County, Michigan 48302**

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POST OFFICE ADDRESS: **(Same as Residence)**

FULL NAME OF SECOND INVENTOR: **RICHARD LEE FINK**

INVENTOR'S SIGNATURE: [Signature] DATE: 5/21/97

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CITIZENSHIP: **U.S.A.**

POST OFFICE ADDRESS: **(Same as Residence)**

FULL NAME OF THIRD INVENTOR: **ZHIDAN LI TOLT**

INVENTOR'S SIGNATURE: [Signature] DATE: 5/21/97

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CITIZENSHIP: **U.S.A.**

POST OFFICE ADDRESS: **(Same as Residence)**

AU971410001
207:12179-P064US

Applicants: Zvi Yaniv, Richard L. Fink, and Zhidan L. Tolt

Attorney's Docket
No. 12179-P064US

Serial No:

Filed: (herewith)

Title: A PROCESS FOR GROWING A CARBON FILM

**VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS
(37 C.F.R. §§ 1.9(f) and 1.27(c)) -- SMALL BUSINESS CONCERN**

I hereby declare that I am

☐ the owner of the small business concern identified below:

☒ an official of the small business concern empowered to act on behalf of the concern identified below:

Name of Small Business Concern: SI Diamond Technology, Inc.

Address of Small Business Concern: 12100 Technology Boulevard, Austin, Texas 78727

I hereby declare that the above-identified small business concern qualifies as a small business concern, as defined in 13 C.F.R. § 121.12, and reproduced in 37 C.F.R. § 1.9(d), for purposes of paying reduced fees to the United States Patent and Trademark Office under Sections 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to, and remain with, the small business concern identified above, with regard to the invention described in

☒ the specification filed herewith, with title as listed above.

☐ the application identified above.

☐ the patent identified above.

If the rights held by the above-identified small business concern are not exclusive, each individual, concern or organization having rights in the invention is listed below* and no rights to the invention are held by any person, other than the inventor(s), who would not qualify as an independent inventor under 37 C.F.R. § 1.9(c), if the person made the invention, or by any concern which would not qualify as a small business concern under 37 C.F.R. § 1.9(d) or a nonprofit organization under 37 C.F.R. § 1.9(e).

*NOTE: Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 C.F.R. § 1.27)

Each such person, concern or organization having any rights in the invention is listed below:

☒ No such person, concern, or organization exists.

☐ Each such person, concern or organization is listed below:

Name: (N/A)

Address: _____
☐ Individual ☐ Small Business Concern ☐ Nonprofit Organization

Name: (N/A)

Address: _____
☐ Individual ☐ Small Business Concern ☐ Nonprofit Organization

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 C.F.R. § 1.28(b)).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

Name of Person Signing: Zvi Yaniv

Title of Person, if Other Than Owner: President and Chief Operating Officer

Address of Person Signing: 12100 Technology Blvd., Austin, Texas 78727

SIGNATURE: _____

Date: 5/21/97